

THE EFFECTS OF PERCENTAGE COMPOSITON OF MILLET STEM ASH (MSA) AND WATER CEMENT RATIO ON THE PROPERTIES COMPOSITE CONCRETE

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ABSTRACT

Water cement ratio and the materials used in making concrete plays significant roles on the compressive strength properties of fresh and hardened concrete. Compressive strength directly affects the degree to which the concrete can be able to carry load over time. The load carrying capacity, cracks, resistance to fire attack, thermal changes, resistance to aggressive action in aggressive environment are often based on the composition and the grade of concrete. This paper presents comprehensive report on the effect of water cement ratio on properties such as compressive strength, slump, flow and workability properties of Millet Stem Ash (MSA) mixes with OPC at 5%, 10%, 15%, 20% and 25% to form concrete and to evaluate whether they are acceptable for use in concrete structural elements. A normal concrete mix with cement at 100% (i.e. MSA at 0%) with concrete grade C25/30 that will attain an average strength of 30N/mm² at 28days was used as a control at design water/cement ratios of 0.60 and increased to 0.65. The results showed that the concrete mixes from MSA at 5% - 25% ratios could be used as a partial replacement to cement

Key words: Concrete composite, Compressive Strength, Millet Stem Ash, Water Cement Ratio, Flow, Slump

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1. INTRODUCTION

Over the years, concrete made from cement, aggregates (inert material) have been extensively studied and a lot of theories were developed on properties of both fresh and hardened concrete as related to the materials, mix ratios, compressive strengths and other properties that are related to construction technology (ASTM, 1981; BS, 1973, 1995 and 1997). However, in the last decade, attention is focused on the development of agricultural waste products as how they could be incorporated into concrete material as a complementary material to partially replace cement at optimal percentage that will give workable and desired strength of the concrete. The deployment of viable waste materials in concrete manufacture provide a satisfactory solution to some of the environmental concerns and problems associated with waste management in every country of the world Nigeria not an exception. Therefore the need to study the behaviour and/or properties of sustainable waste material such as Millet Stem Ash (MSA) concrete for building construction cannot be overemphasized. The performance of the entire building structure is a function of the quality of each material that constitutes the building. Consequence to the importation of most materials, the high cost of building materials both local and imported has made the ownership of house beyond the reach of most Nigerians [Madedor, 1992]. This has resulted in the shortage of accommodation in every urban settlement of the country with the attendant high cost of rent. Consequently, the use of locally produced building materials, agricultural and industrial wastes and products to construct houses has to be investigated and encouraged. The assessment for substitute uses and economic exploitation of naturally occurring local materials and agricultural or industrial wastes and products remains an important area of research interest in the drive towards the overall development of any nation. The current challenge facing the governments of most developing nations like Nigeria is how to provide good accommodation for the growing population at relatively low cost. For this research basic concrete mix of grade C25/30 and design water cement ratio of 0.60 and an increment to 0.65 was examined for:

0% MSA, 100% Cement, (0.5-32) mm fine- coarse aggregate mix concrete (Control),
 5% MSA, 95% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
 10% MSA, 90% Cement, (0.5-32) mm fine/coarse aggregate mix concrete,
 15% MSA, 85% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
 20% MSA, 80% Cement, (0.5-32) mm fine-coarse aggregate mix concrete,
 25% MSA, 75% Cement, (0.5-32) mm fine-coarse aggregate mix concrete.

2. METHODOLOGY

The materials used in the production of the concrete cubes are; sand, gravels, cement, millet stem ash and water.

The Millet Stem was collected from farms around Abuja -Niger-Kaduna-Zaria and transported to; Julius Berger Plc (Jbn Plc) and Quality Assurance & Control (QA&C), Mpape-Abuja, laboratories in FCT, for preliminary analysis for suitability for use in concrete.

The coarse aggregate was obtained within Gwagwalada-Abuja-FCT and transported to JBN PLC, QA&C laboratory, Mpape-Abuja, FCT. The aggregate was washed and allowed to dry naturally, to free it from dirt and impurities according to BS 812, 1975. The cement used was Dangote cement obtained at Gwagwalada-Abuja-FCT. Millet Stem is a waste product in millet farms in rural areas of FCT, Niger State and Kaduna Stated.

The source of water used for this work is the borehole water situated in the JBN PLC, QA&C laboratory, Mpape-Abuja, FCT.

2.2. Experimental procedures

The Millet Stem burnt and its ash collected. The ash was allowed to pass through sieve 0.63 millimeters to the same fineness of cement and was followed by preliminary investigation of the constituent material of the ordinary Portland cement (OPC) and the millet stem ash (MSA). The following preliminary analysis tests were conducted on the materials in accordance with the various codes, to determine their suitability for concrete making: Specific Gravity Test; Aggregate impact Value Test; Silt Content Test; Moisture Content Test and Sieve Analysis Test;

Materials were batched by weight; measurement was done normally using head pan and a balance. The concrete mix was designed in accordance with the British design mix BS 8110. Mixing was done using rotary concrete mixer. The fine and coarse aggregate, cement, millet husk ash was mixed all together in the concrete mixer thoroughly to achieve the final uniformity. The required quantity of water to cement ratio of 0.60 and 0.65 was added.

Workability test on the concrete was carried out. The slump cone was placed on a flat non-porous surface and held down by the foot. The mould was then filled in three layers. Each layer was compacted. After the third layer has been tampered, the slump cone was removed immediately by raising it up vertically. The height of the slump cone was determined. The measurement was taken from the top of the slump cone to the top of the concrete (Figure 1). The slump was measured as the difference between the heights of the cone to the height of the slump concrete. The flow test was carried out on fresh composite concrete for the various percentage composition of millet stem ash. The flow table is wetted. Flow test cone then placed on the flow table, then filled with the composite concrete in two layers, each layer tamped 10 times. The cone was lifted up after 30 seconds. The concrete was allowed to flow. The table was lifted up 40mm and dropped 15 times. The diameter of the flowed concrete was measured, Figure 2.

The compressive test commenced with mixing of the various measured percentages of MSA and cement in concrete mixer and adding 0.60 or 0.65 % water – cement ratio. The mixture now poured in cubes moulders of size 150mm x 150mm x 150mm. The concrete was placed in three layers and each layer was tampered. The surface of the concrete was smoothen with a steel float and then covered with a sack and left for 24 hrs. The cubes in mould were placed in the laboratory for 24 hrs. The concrete cubes were then strike out and placed immediately in moist curing tanks for 7, 21, 28 and 56 days. After each of the stated days, the cubes was removed from the tank and allowed to dry in open air before being subjected to compressive strength. The compressive strength of the cube sample was determined in accordance with the standard procedure given in BS 2080 (BSI, 1970). The weights of the sample were always taken before the compressive strength was concluded. A three cubes sample was crushed in the 7th, 21st, 28th and 56 day respectively as shown in Figure 3. The maximum loads were recorded and the compressive stress computed.



Figure 1 Slump Test



Figure 2 Flow Test



Figure 3 Compressive Strength Test Machine

3. RESULTS AND DISCUSSIONS

Tables 1 and 2 presents the slump and flow test results on fresh concrete of grade C 25 and C 30 for the various percentage of MSA (0, 5, 10, 15, 20, 25, 30 and 35 %). It was observed from Figures 3 and 4 that the slump and the flow of the fresh concrete decreases with increase in percentage of composition of MSA. The variation of compressive strengths of hardened concrete as presented in tables 4 and 5 and the graphical comparison presented in Figure 5 and 6. It was observed that the compressive strength increase with age irrespective of the percentage of the composition of the MSA. However, the compressive strength decreases with increase in percentage of MSA at corresponding age. The weights and densities of the concrete at a given percentage of MSA at a specified age as present in tables 5 and 6. The variation of the densities and weights of the composite concrete with the age and percentage composition of MSA were compared using Figures 7 to 10, for the water – cement ratios of 0.60 and 0.65. The graphs showed that both the weight and the densities decreased sinusoidal with the age of composite. Also, the corresponding values of weights and densities decreased with increase in percentage of MSA in the composite concrete.

Table 1 Slump/Flow of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	Slump Test (mm)	Flow Test (mm)
100% OPC, 0% MSA	75	430
95% OPC, 5% MSA	64	360
90% OPC, 10% MSA	15	260
85% OPC, 15% MSA	27	320
80% OPC, 20% MSA	20	280
75% OPC, 25% MSA	20	300
70% OPC, 30% MSA	10	100
65% OPC, 35% MSA	5	50

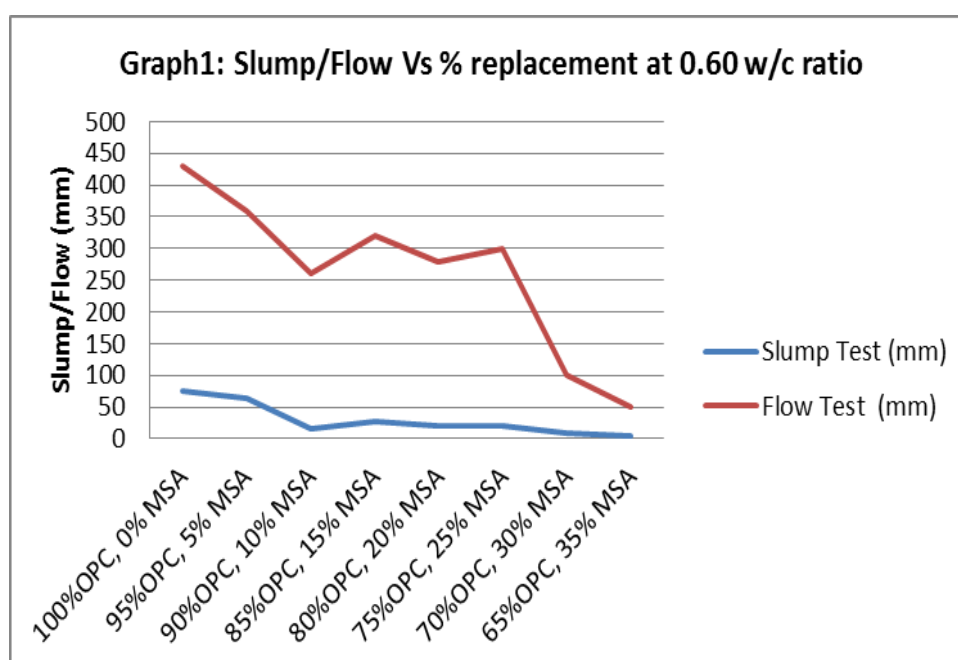


Figure 4 Slump and Flow at 0.60 % water- cement ratio

Table 2 Slump/Flow of concrete grade C25/30 at water cement ratio of 0.65

% Replacement at water cement ratio of 0.65 and concrete grade C25/30	Slump Test (mm)	Flow Test (mm)
100% OPC, 0% MSA	145	430
95% OPC, 5% MSA	195	510
90% OPC, 10% MSA	62	350
80% OPC, 20% MSA	110	420
75% OPC, 25% MSA	90	400

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The compressive strength of the hardened concrete decreases as % replacement of MSA increases from 5% - 25% compared with the 0% MSA. The compressive strength drops by (20%-30%) with the increase in water cement ratio as shown in the table and graph:

Table 3 Compressive Strength (N/mm²) of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	Compressive Strength (N/mm ²)			
	7 days	21 days	28 days	>56 days
100% OPC, 0% MSA	29.8	34.4	34.2	38.2
95% OPC, 5% MSA	28.9	35.8	35.1	36.4
90% OPC, 10% MSA	20.9	23.8	23.8	27.6
85% OPC, 15% MSA	16	20.2	20.4	22.2
80% OPC, 20% MSA	14.4	17.3	18.2	17.8
75% OPC, 25% MSA	15.6	18.9	19.6	20.8
70% OPC, 30% MSA	Collapsed and failed during curing in the curing tank			
65% OPC, 35% MSA				

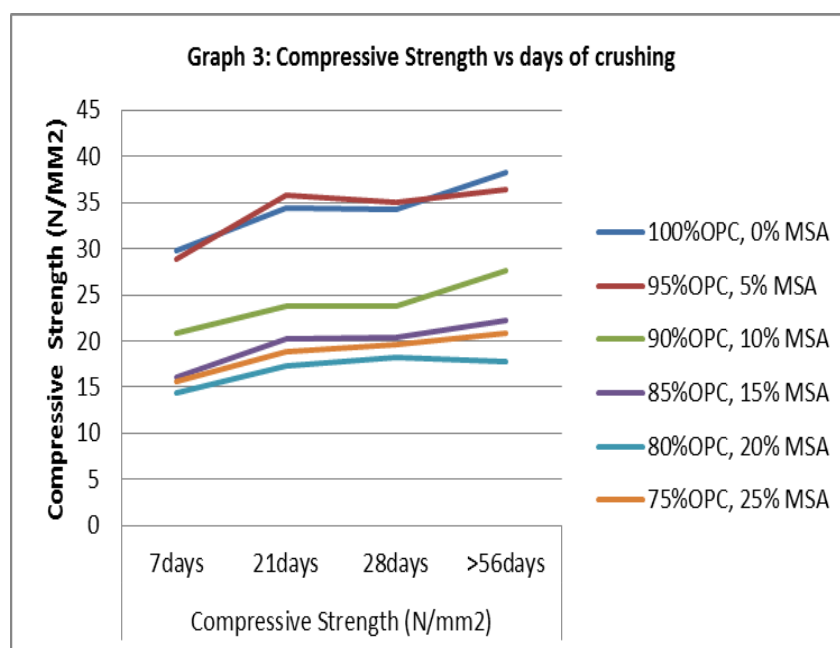


Figure 5 The compressive strength of composite concrete at water – cement ratio of 0.60

Table 4 Compressive Strength (N/mm²) of concrete grade C25/30 at water cement ratio of 0.65

% Replacement at water cement ratio of 0.65 and concrete grade C25/30	Compressive Strength (N/mm ²)			
	7 days	21 days	28 Days	>56 days
100%OPC, 0% MSA	23.3	28.9	28.2	30.7
95%OPC, 5% MSA	20.4	23.8	23.3	24.9
90%OPC, 10% MSA	13.6	15.1	17.1	17.8
80%OPC, 20% MSA	12.2	13.6	14.2	14.2
75%OPC, 25% MSA	12.7	14.0	14.7	14.7

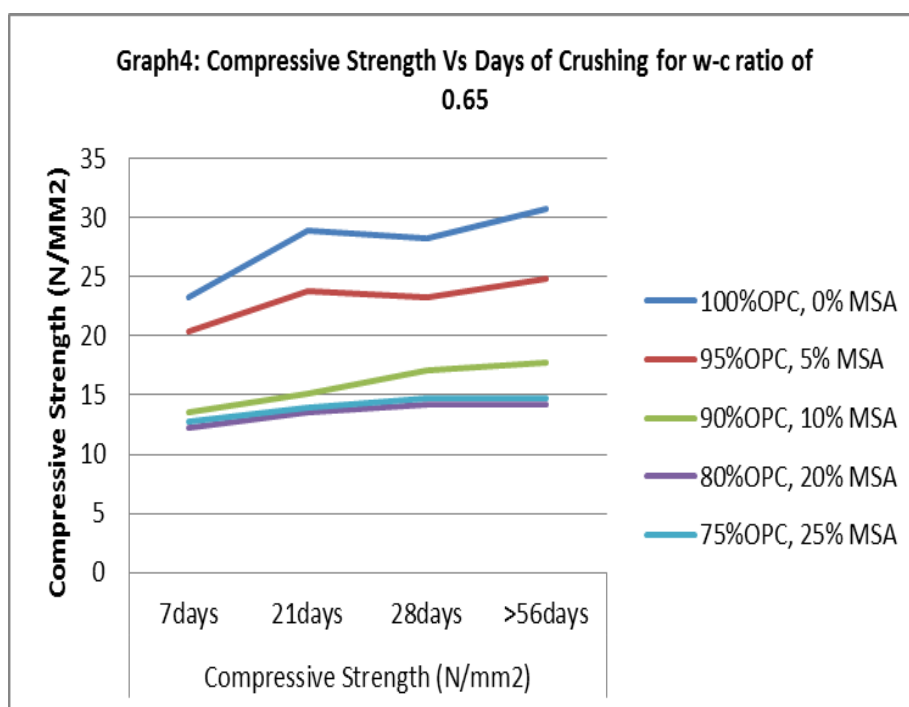


Figure 6 The compressive strength of composite concrete at water – cement ratio of 0.65

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Table 5 Weights (kg) and Densities (kg/m³) of concrete grade C25/30 at water cement ratio of 0.60

% Replacement at water cement ratio of 0.60 and concrete grade C25/30	Crushing Days	Weight (kg)	Density (kg/m ³)
0%	7	7.961	2359
	21	7.959	2358
	28	8.090	2397
	>56	8.014	2375
	Average	8.006	2372
5%	7	7.980	2364
	21	8.026	2378
	28	8.015	2375
	>56	7.968	2361
	Average	7.997	2370
10%	7	7.866	2331
	21	7.889	2337
	28	7.926	2348
	>56	7.880	2335
	Average	7.890	2338
15%	7	7.971	2362
	21	7.983	2365
	28	7.995	2369
	>56	7.991	2344
	Average	7.985	2360
20%	7	7.833	2321
	21	7.871	2332
	28	7.890	2338
	>56	7.873	2333
	Average	7.867	2331
25%	7	7.953	2356
	21	7.953	2356
	28	7.926	2348
	>56	7.883	2336
	Average	7.929	2349

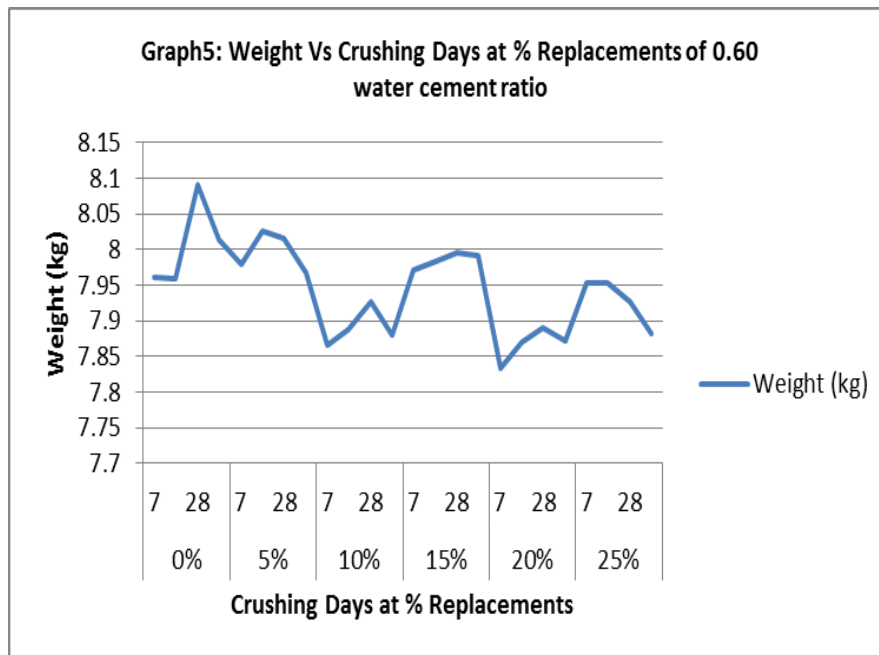


Figure 7 The variation in weight of the composite concrete with curing age and % replacement at water – cement ratio of 0.60.

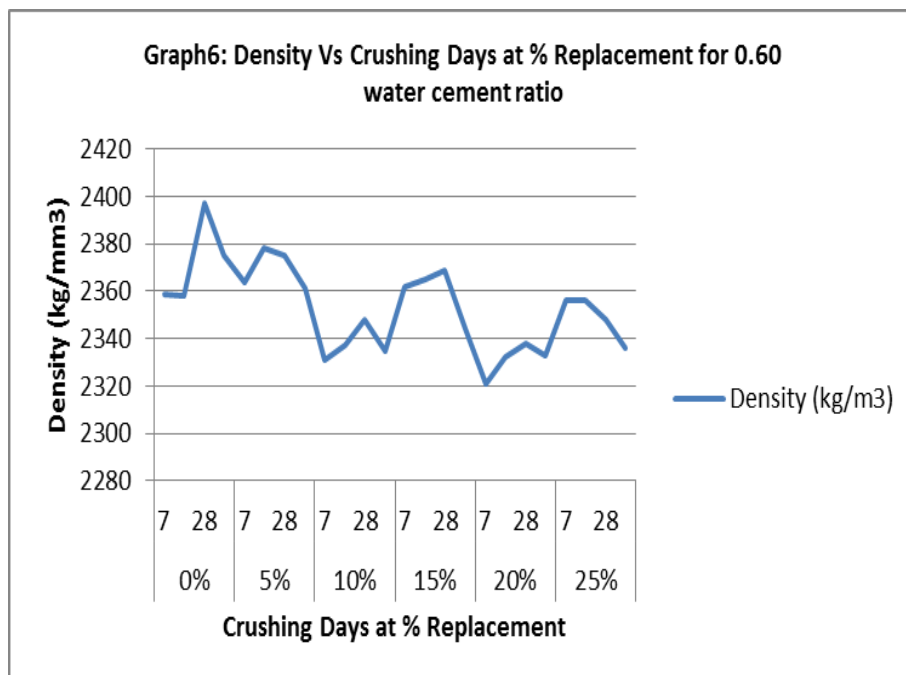


Figure 8 The variation in density of the composite concrete with curing age and % replacement at water – cement ratio of 0.60.

The Effects of Percentage Composition of Millet Stem Ash (MSA) and Water Cement Ratio on The Properties Composite Concrete

Table 6 Weights (kg) and Densities (kg/m³) of concrete grade C25/30 at water cement ratio of 0.65

% Replacement at water cement ratio of 0.65 and concrete grade C25/30	Crushing Days	Weight (kg)	Density (kg/m³)
0%	7	7.889	2337
	21	7.869	2331
	28	7.916	2345
	>56	7.874	2333
	Average	7.887	2337
5%	7	7.942	2353
	21	7.974	2363
	28	7.916	2345
	>56	7.882	2335
	Average	7.929	2349
10%	7	7.836	2320
	21	7.827	2319
	28	7.882	2335
	>56	7.866	2331
	Average	7.853	2326
20%	7	7.955	2357
	21	7.926	2348
	28	7.923	2348
	>56	7.959	2358
	Average	7.941	2353
25%	7	7.790	2308
	21	7.765	2301
	28	7.806	2313
	>56	7.717	2287
	Average	7.770	2302

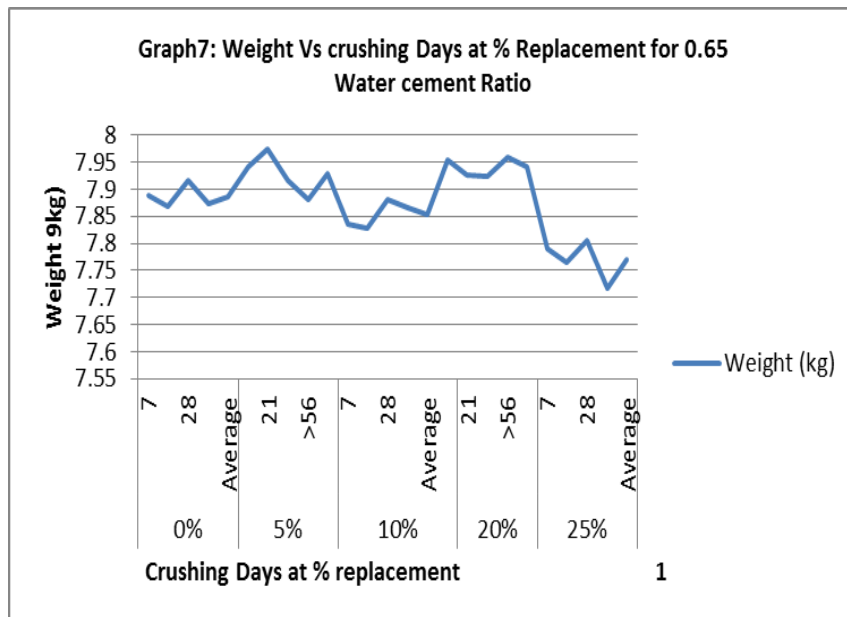


Figure 9 The variation in weight of the composite concrete with curing age and % replacement at water – cement ratio of 0.65.

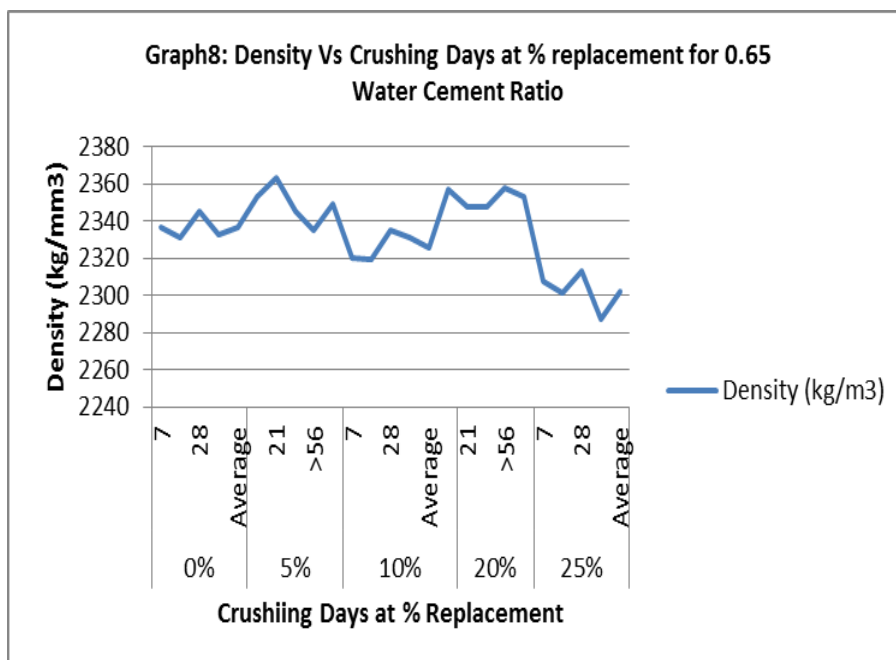


Figure 10 The variation in density of the composite concrete with curing age and % replacement at water – cement ratio of 0.65.

4. CONCLUSIONS

The results show that:

- MSA concrete can be used for replacement of Portland cement in concrete. The compressive strength at 28 days is 20N/mm² for 25% MSA concrete.
- The increase in water cement ratio reduces the compressive strength of the concrete composite.
- The density of MSA concrete is lighter compared with the normal concrete at 0% MSA even with the increase in water cement ratio.

The Effects of Percentage Composition of Millet Stem Ash (MSA) and Water Cement Ratio on The Properties Composite Concrete

- The workability of the concrete decreases as the percentage of MSA increases but still workable at 25% MSA replacement, but becoming unworkable at water cement ratio of 0.60.

5. RECOMMENDATIONS

Further studies should be carry out on:

- Chemical characterization of the Millet Stem Ash
- Morphology and microstructure of the concrete made from MSA concrete.
- Influence of Initial and final set time of MSA concrete.
- The shrinkage and creep test to determine the long term suitability of MSA concrete for structural elements in structure.

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